

On Photography in the Transit of Venus. By R. A. Proctor.

Mr. Christie misapprehends, it appears to me, the object of my Note on this subject: I did not desire to "raise an issue;" but, as Capt. Abney had commented on my more public statements, I thought it well to explain their real purport.

Passingly, I may express surprise that Mr. Christie considers *Venus* and the Sun likely to be equally affected by photographic irradiation. The blackness of *Venus* and of sky round Sun may be equal, but Sun's brightness near limb is very inferior to his brightness near centre. Any arrangement by which flat photographs were obtained, so far as parts of Sun not *very* near the limb were concerned, would exaggerate the difference of irradiation, for the limb itself, as compared with the edge of *Venus* in transit.

Dr. Rutherford, in *Papers Relating to the Transit of Venus* (Washington, 1872), says, "the photograph of the Sun will have a greater or less diameter *by many seconds of arc*, according to the energy of the rays which have produced the image; and this discrepancy may be produced by a change in the aperture, in the length of exposure, in the transparency of the atmosphere, in the hour of the day, or in the sensibility of the chemicals." To assume that the diameter of *Venus* will be affected in the same exact degree, though the conditions are so different, is somewhat unsafe. The papers from which I have just quoted dealt fully (three years ago) with all the points raised by Mr. Christie, Dr. De La Rue, and Capt. Abney, besides discussing some others which they have not mentioned. But, in any case, it would be a waste of time to discuss these points, because the examination of the photographs, if conducted without favour for preconceived opinions, must lead to a tolerably exact determination of the relative value of the various methods, the long focal, the photoheliographic, and the Daguerrean.

Referring generally to the recent transit-results, I may remark that two points seem clearly established already: (1) Contact observations, whether telescopic or photographic, have been shown not to possess the accuracy required for *improving* our estimates of the solar parallax. In 1882 transit-chords, and especially mid-transit observations, will have to be secured. (2) Observations with a low Sun must be avoided. I think 15° the very lowest solar altitude for effective observations; and observations with a solar altitude of 20° or 25° would be better, notwithstanding the diminution of parallax. I find, from projections which I have constructed of the next transit, that these two conditions will introduce serious geographical difficulties. In fact, the efforts necessary to secure success will be greater than the mere observation of *Venus* in transit would justify.

One circumstance of some importance in its bearing on contact observations remains to be mentioned. Referring to the

arc of light seen round the part of *Venus* outside the Sun, between the moments of external and internal contact, it was remarked at the last meeting that "an atmosphere round the planet could not account for the phenomenon, because such an atmosphere would refract the light, dispersing it between the planet and the earth, so that it could not appear as the brilliant ring described, nor retain (having passed through the refracting medium) a sufficiently active power to photograph itself." This reasoning is based on an error. A pencil of rays proceeding from any point in the Sun, and refracted by the planet's atmosphere in such a way as to reach the terrestrial observer's eye, remains appreciably a pencil of parallel rays *after* as it was *before* the refraction took place, and setting absorption aside, conveys as much light to the eye. Another pencil of equal size, passing nearer to the planet's surface would, no doubt, pass between the Earth and planet, while one passing higher in the planet's atmosphere would pass outside the Earth so to speak. The three pencils thus considered, and others intermediate to them and beyond them, are dispersed, that is, are separated from each other after refraction, and to a greater degree angularly than they were separated before refraction; but even on their original course they would have been several miles apart before reaching the Earth's distance from the Sun. No pencil of rays which setting out from a point on the Sun would, at the Earth's distance, fall on the object-glass of a telescope, would be made appreciably larger at the same distance from the Sun by being refracted through a planet's atmosphere. Indeed, it is easy to see that if the principle were correct on which that reasoning is based, we ought not to see the setting or rising Sun, as raised above the horizon by refraction. A slight extension of the consequences of this principle would also prove that, since the Sun's rays diverge in all directions, we ought never to see the Sun at all.

It will be manifest, on considering the optical conditions involved, that the light first seen by refraction round the part of *Venus*'s limb most remote from the solar outline (say at ingress, after external and internal contact) must appear to form an arc coincident with the limb. This light really comes from the part of the Sun nearest to *Venus* (that is, from the part behind her disk). But as she moves further on to the Sun's disk, light from this part of the Sun, to reach the eye, must pass higher and higher above the surface of *Venus*. Nevertheless the *inner* edge of the brightening at this point will coincide with the limb, up to the moment of interior contact, unless the atmospheric refraction of *Venus* be greater than is necessary to raise the whole disk of the Sun just above the horizon of *Venus* at the time when geometrically the whole globe of the Sun is just below that horizon. But even if the atmospheric refraction for *Venus* were greater than this (though this value would exceed terrestrial refraction as 100 to 77) the apparent interval between the ring

and the disk of *Venus* would be undiscernible by the observer on the Earth, because the rays from the inside of the ring, really proceeding from the part of the Sun opposite to (that is, most remote from) the place of contact, would not pass more than a mile or two above the surface of *Venus*, on any probable hypothesis as to the refractive power of the planet's atmosphere.* The bright spot near the pole (assuming for the moment that we know the true axial position of *Venus*) might be explained as indicating clearer air over the planet's polar regions.

It was to be expected that this ring of light would be bright—brighter even than the Sun's limb. Maskelyne, in his account of the Transit of 1769,† as seen at Greenwich, recorded enough to show that *Venus* has an atmosphere, and that with a good telescope the bright ring would always be seen round the dark part of the limb, thus preventing the *exact* timing of internal contact.

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On the Application of the Method of Limiting Apertures to the Photometry of Naked-eye Stars. By E. B. Knobel, Esq.

In making observations with the Astrometer, which I had the honor of submitting to the Society last December, it occurred to me that if I removed the silver surface of the mirror of my telescope, I should probably be able to reduce the light of naked-eye stars so much as to convert them into virtually telescopic stars—understanding by a telescopic star, one which requires an aperture larger than the pupil of the eye for its exhibition.

Taking advantage of the silver surface being somewhat broken up, I dissolved it off, and for the past six weeks have devoted myself exclusively to observations with an *unsilvered* glass mirror.

The telescope in this form does not differ materially from the instrument called a Helioscope, devised by Sir John Herschel for solar observation; but instead of employing a prism with reflection from external surface, as he suggests, I have retained the silvered plane or flat, so that the only difference made is in the silver surface of the mirror.

Though considerable advantage would have resulted from using a prism with reflection from external surface only, for the photometrical observation of the brightest stars (a method which I hope to be able to undertake at a future time,) yet my prin-

* In considering this subject it must not be forgotten that the apparent diameter of *Venus* is increased by her atmospheric refraction.

† *Phil. Trans.* 1768, p. 367.